BOLETÍN DE LOS OBSERVATORIOS DE TONANTZINTLA Y TACUBAYA, VOL. 4, N°28, 1967.

ON A DUST RICH REGION OF THE ORION NEBULA

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In the Introductory Remarks of the Monochromatic Atlas of the Orion Nebula, Wurm and Rosino (1965) point out the particular structure of the south-east region of the central part of the nebula. This zone falls in the vicinity of Θ^2 Orionis. Differences in projected structure are clearly apparent, between photographs taken in the continuum below $\lambda3650$, and those obtained in the continous light at $\lambda5200$. These authors correctly assume that, for that region, atomic recombination does not dominate in the continuum at wavelengths below $\lambda3650$. On the same grounds, one can conclude that only two processes might be responsible for the emission of the ultraviolet continuum; namely, electron scattering and scattering of stellar light by dust particles. The electron density in the neighborhood of Θ^2 Orionis is low, therefore only the second mechanism must be considered. In fact the differences in structure give support to the results derived in a previous paper (Méndez, 1965), concerning the value of the albedo of dust immersed in the nebula. In that paper, it was found that the albedo for $\lambda5200$ is about 0.14, whereas for $\lambda3480$ (the peak of transmission of the UV filter used) the albedo is 0.45. In other words, the photographic appearence of the nebular structure should be more diffuse, at the shorter wavelengths, than for the case of longer wavelengths, since the efficiency of scattering is three times higher. Moreover, since the scattered light comes from Θ^2 Orionis, an O9 star, there will be more energy in the ultraviolet than in the spectral region close to $\lambda5200$ (at least by a factor of 2.5). Consequently, a more extended structure should be present in the UV photographs, if there is an appreciable amount of dust close to the star. The above remarks agree well with what is actually observed around Θ^2 Orionis.

The existence of large amounts of dust in that region might be also responsible for three conspicous condensations located in the immediate vicinity of Θ^2 Ori, with dimensions of a few seconds of arc. Those fluctuations in density can be easily seen in the Wurm-Rosino Atlas; however, a clearer view can be obtained from a photograph taken with the 200-inch telescope, at Mt. Palomar, by G. Münch. This photograph is presented in an earlier paper by the author (Méndez, 1967). Two of the condensations have been studied spectroscopically, they are marked by R and 11 in Figure 1 of that paper. The spectra of the objects, at 85 A/mm., show particularly strong continua. The dust continuum component of condensation 11 is remarkably high, indicating an appreciable content of solid grains. At a distance of the nebula of 500 pcs. the linear dimensions of condensation 11 are 1500 a.u. and the thermal diffusion time will then be of the order of 600 years. These features, thus, either are very short lived and are being continuously created and destroyed, or are subject to stabilizing forces. It is interesting to notice that condensation 11 is clearly associated with a central star —which is variable— but not the other ones. From surface brightness determinations, and also from the [OII] $\lambda3726$-29 ratio, one obtains an electron density of 2.3×10^3 cm^{-3}, while the neighboring field has a density of about 500 cm^{-3}. The total mass being almost 10^{27} gms.

Kinematically the object presents interesting features, which are of cosmogonic relevance. Radial velocities were measured in a multislit plate, kindly loaned to the author by G. Münch, finding that the radial velocities of the gas in the condensation are negative with respect to its surroundings which, in turn, are moving towards us. In addition, the brighter edge of the object is directed towards Θ^2 Orionis, and is moving with a negative radial velocity of 19 km/sec., again with respect to its neighborhood. It is evident that the gas, being at higher pressure than the surroundings, should expand, and it will do so symmetrically. Inspection of the photograph does not show such symetry; the condensation is elongated toward Θ^2 Ori, with its brighter edge pointing to the star. One must conclude that the O9 stars is affecting dynamically the condensation, through the so-called rocket effect, studied by Oort and Spitzer (1955). The negative radial velocity of the bright edge suggest that the exciting star must be located between the condensation and the Sun. Since the radiation of the O9 star induces the material to expand, it does work, which must be used both in increasing the expansion velocity and in compensating the cooling by dust (dust radiates away energy, which it has acquired from the surrounding gas). If the second effect is ignored one obtains the relation (Oort and Spitzer, 1955):

$$V_{ob} = 3.92 \frac{kT_e}{m_H} \, log \, \frac{N_o}{N}$$

where N is the actual observed density, and N_o is the density when the expansion started. T_e is the electron density, which will be taken as 10^4 °K. Adopting for V_{ob} the value of 19 km/sec., one derives for the value of the initial density 5.1×10^{-20} gm/cm^3. This number might represent the density of the cloud from which the imbedded star was formed. A cloud with such a density could contract to a body of stellar dimensions, considering free fall as a lower limit, in less than 300 000 years. The Orion Nebula is ten times younger (Vandervoort, 1964); therefore, if the star associated with the condensation is coeval with the nebula, the density of the cloud which produced the star should be 5.1×10^{-18} gm/cm^3, equivalent to an atomic density of 3×10^6 cm^{-3}, which might be difficult to accept for the Orion Nebula medium. In conclusion, one may state that the density needed to produce stars such as the one imbedded in the condensation lies in the range: 5.1×10^{-18} gm/cm^3 $> \varrho > 5.1 \times 10^{-20}$ gm/cm^3 or in other units as 3×10^6 cm$^{-3} > n_{II} > 3.1 \times 10^4$ cm^{-3}.

The author is indebted to Dr. G. Münch for making available two multislit spectrograms of the region of interest. Dr. G. Haro kindly supplied several plates of the Orion Nebula to investigate the variability of the star.

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